THE WEATHER AND CIRCULATION OF JUNE 1953[1]—

The Second Successive June with Record-Breaking Drought and Heat

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DROUGHT AND HEAT

Extremely dry weather prevailed over the lower Mississippi Valley, Southern Great Plains, and Southwest during June 1953. Much of this vast area received less than 25 percent of normal rainfall and nearly all of it less than 50 percent (Chart III–B). The dry spell over the South, which began in the last third of May, resulted in extensive deterioration of crops and pastures and desiccation of ponds and streams.

The most severe drought conditions existed over western Texas and in the Rio Grande Valley where, except for brief periods of temporary relief, precipitation has been deficient for nearly 3 years. For example, records at Del Rio and Big Spring, Tex., show that these stations have received respectively only 38 percent and 50 percent of their normal precipitation during the past 33 months. The bed of the Rio Grande dried up at Laredo, Tex., this month for the first time in recorded history. Amarillo, Tex., experienced its driest June on record with rainfall totalling a meager 0.01 inch. Newspaper reports have called this the worst drought in Texas history and have described the appearance of a new "dust bowl" where crop lands have been turned into sand dunes; most ponds, lakes, and streams are bone dry; and crops are stunted or dead.

[1] See charts I–XV following p. 178 for analyzed climatological data for the month.

Other States seriously affected by drought were Oklahoma, Arkansas, Tennessee, and Mississippi, where widespread crop damage and water shortages were reported. Record or near record low rainfall amounts were observed at several stations in these States. One of these was Memphis, Tenn., with 0.04 inch, the lowest amount on record for June.

A prolonged and extreme heat wave accompanied and contributed to the drought, except in southern California and Arizona where temperatures averaged below or near normal (Chart I–B). Maximum temperatures in the 90's or higher occurred nearly every day of the month over most of the drought area. In the Rio Grande Valley there were very few days when afternoon temperatures did not reach 100°. At Laredo, Tex., the maxima varied between 98° and 107° with only 4 days below 100°. Twenty-one consecutive days with maximum temperatures of 100° or more at Abilene, Tex., set a new record for June. At many stations in Texas, Oklahoma, Kansas, New Mexico, Louisiana, Arkansas, and Tennessee monthly mean temperatures were the highest on record for June. At Memphis, Tenn., and Lake Charles, La., June 1953 was not only the warmest June on record but also the hottest month ever observed.

Many of the new heat records established this June just barely exceeded previous records set only last June [1]; while in many places, especially in the central Plains

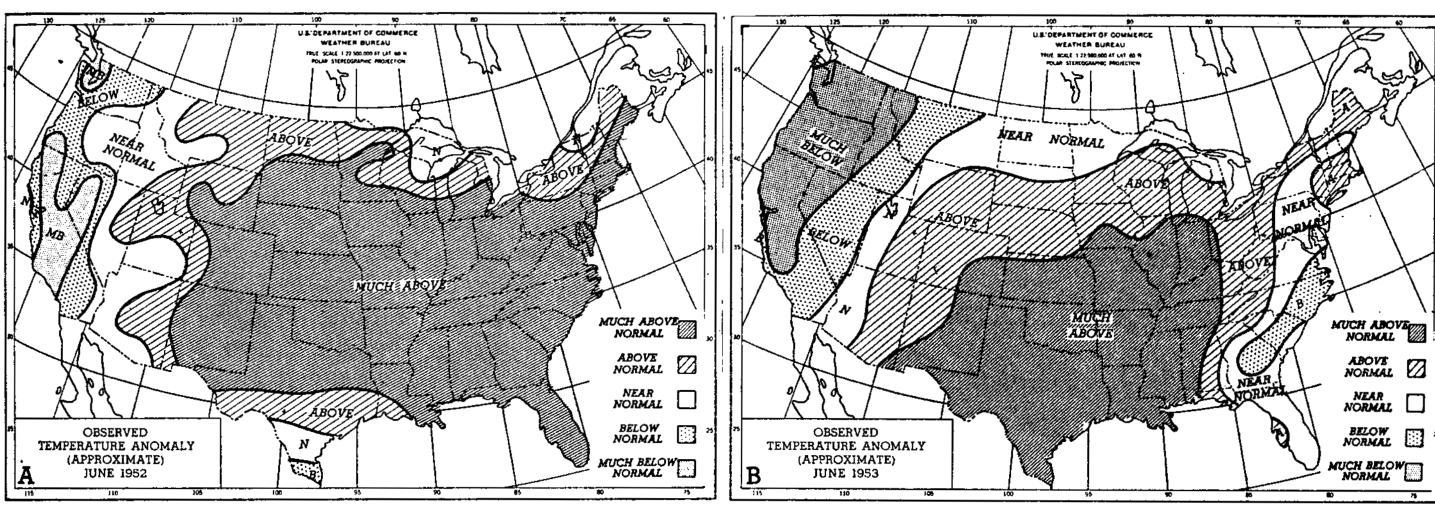


FIGURE 1.—Monthly mean surface temperature anomalies for (A) June 1952 and (B) June 1953. The classes above, below, and near normal occur on the average one-fourth of the time, while much above and much below each normally occur one-eighth of the time. Note the marked similarity in overall pattern, especially the coincidence of much above normal temperatures over a broad area in the central part of the United States.

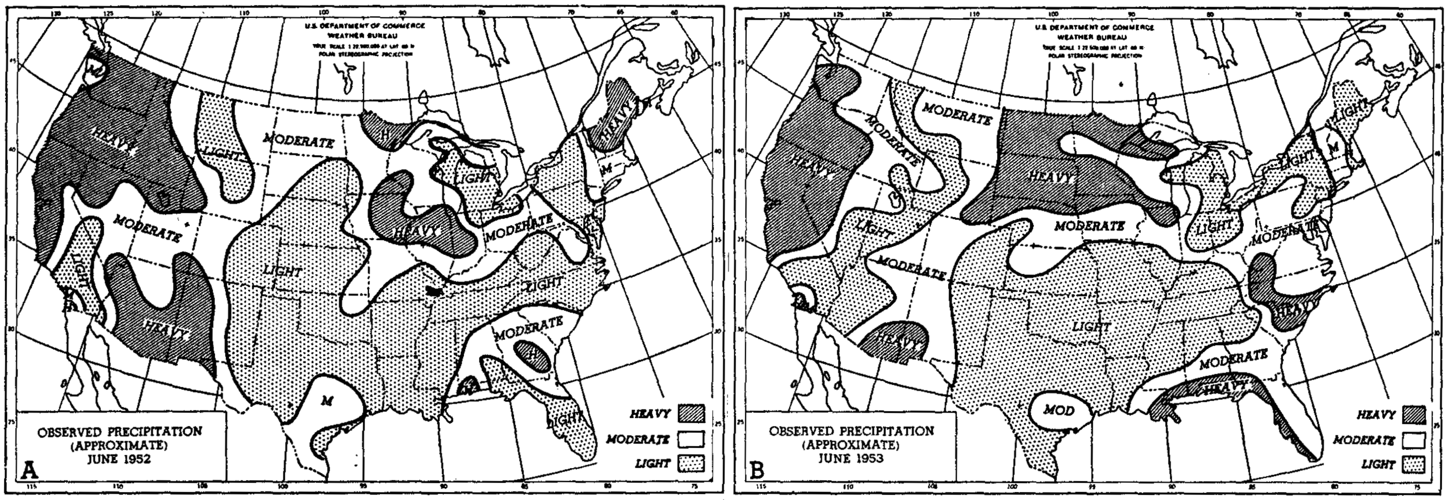


FIGURE 2.—Anomalies of total monthly precipitation for (A) June 1952 and (B) June 1953. The classes light, moderate, and heavy occur on the average one-third of the time. Note general coincidence of like precipitation classes, especially large area of light rainfall over South Central United States in both years.

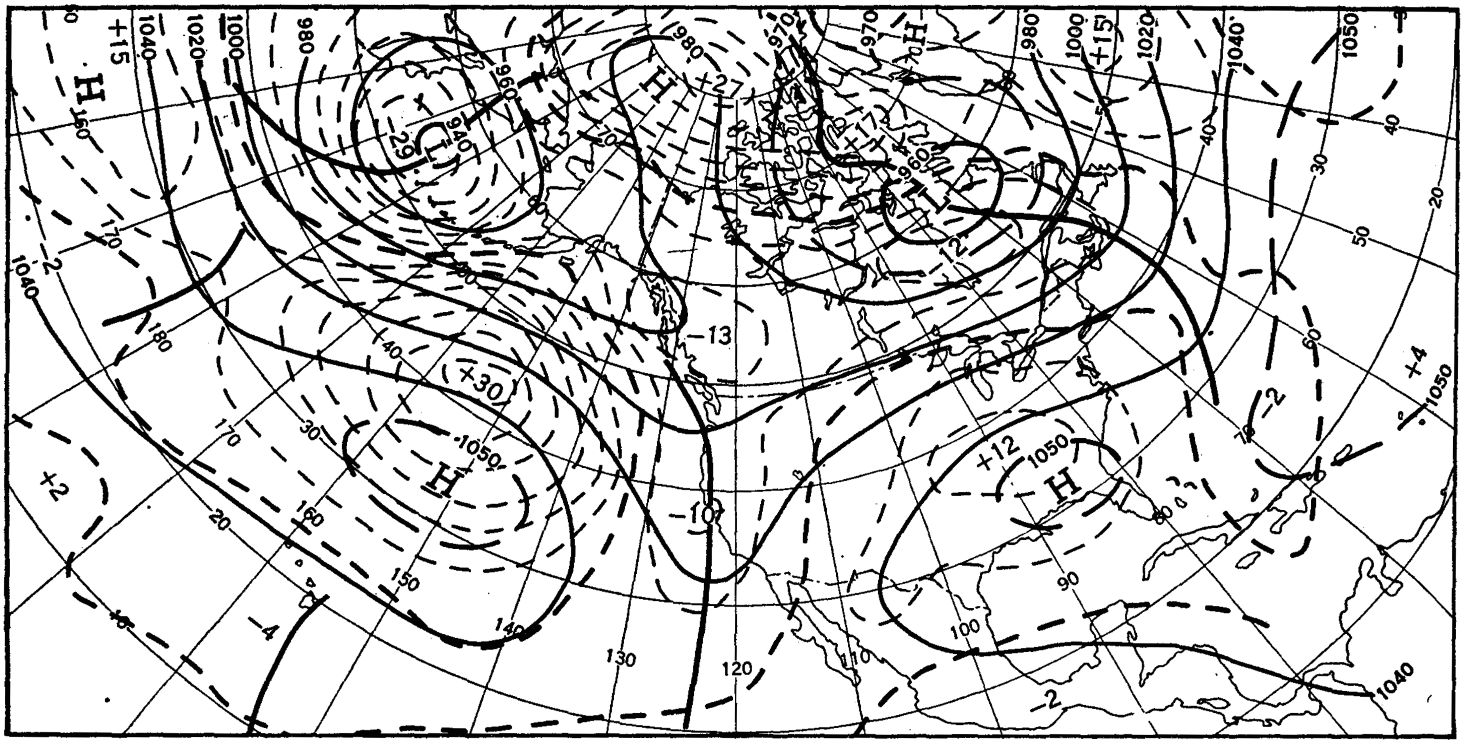


FIGURE 3.—Mean 700-mb. chart with height contours and departures from normal (both labeled in tens of feet) for May 31–June 29, 1952. Circulation over much of United States last June was dominated by a strong subtropical ridge over the Mississippi Valley, accompanied by heat and dry weather over large portions of the country. (See figs. 1–A and 2–A.)

and central Mississippi Valley, this June's heat was only slightly surpassed by that of June 1952. The basic similarity of the temperature anomaly patterns over the entire United States for June 1952 and June 1953 is readily apparent in figure 1, where mean surface temperature anomalies are analyzed in terms of five classes. Note the large area from the southern and central Rockies eastward to the Ohio Valley where temperatures in both years averaged much above normal, a class which normally occurs in only 1 out of 8 years. The most notable differences between the two patterns were along the east coast, where this June was considerably cooler than last year, and in southern Texas, where this June was substantially hotter. In the Far West cool weather was observed in both years, but this June was somewhat colder as indicated by the more extensive area of much below normal temperatures in figure 1–B. In fact, at several stations in this area this was the coldest June ever observed.

Precipitation regimes over the United States in June 1952 and June 1953 were also remarkably similar (fig. 2). Light rainfall occurred over a broad region from Colorado and New Mexico eastward to the Appalachians in both months, generally over the same region where much-

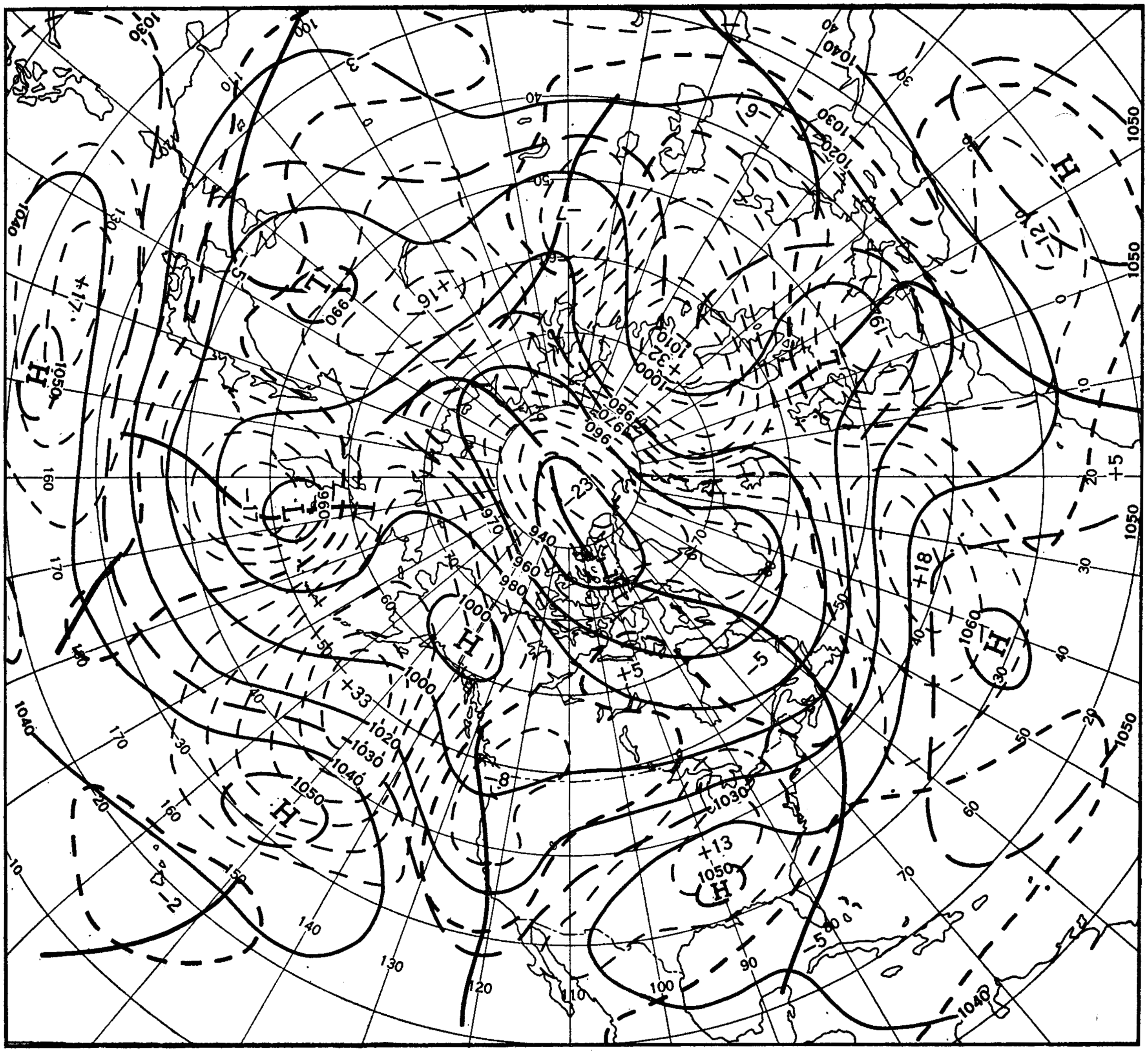


Figure 4.—Mean 700-mb. chart with height contours and departures from normal (both labeled in tens of feet) for May 30–June 28, 1953. Note remarkable similarity in basic wave pattern at middle latitudes from western Pacific to central Atlantic between this June and last June. (See fig. 3.) Once again a well-developed continental anticyclone dominated the circulation over the United States with accompanying heat wave and drought. (See figs. 1–B and 2–B.)

above-normal temperatures were observed (fig. 1). Another sizeable area where precipitation was similar in both months was in the Far West where heavy amounts occurred. Other coincidences between precipitation regimes occurred, although on a smaller scale, such as heavy precipitation in southern Arizona and New Mexico, and light in the Lower Lakes, New York, and New Jersey. The major differences were over the northern Plains, the Carolinas, and Florida where this June's precipitation was considerably greater, and over New England where it was considerably lighter than last June's.

RELATED CIRCULATION FEATURES

Since June 1952 and June 1953 showed such good correspondence in both precipitation and temperature regimes over large areas of the United States it is not surprising that the mid-tropospheric circulation patterns were very similar in both months over most portions of North America and adjoining oceans (figs. 3 and 4). The entire wave train from the western Pacific to the Central Atlantic was virtually identical in trough and ridge positions and in locations of major height anomaly centers. Immediately associated with the heat and drought over much of the United States in both months was the stronger-than-normal subtropical High cell (centered over the South) whose pronounced anticyclonic circulation dominated most of the country south of the northern Border States and eastward from the Plateau. Other common features of figures 3 and 4, which were undoubtedly of direct importance in maintaining a warm anticyclone over the United States, were a deeper-than-normal trough along the west coast, faster-than-normal flat westerly flow along the Canadian border, and an abnormally strong ridge over the east central Pacific. Last year Klein [1] demonstrated that the circulation pattern of June 1952 was typical of summer heat waves over the central and eastern United States. It is obvious that the circulation of June 1953 fits this "model" heat wave circulation pattern rather well.

The association in summer between the upper-level continental anticyclone and hot, dry weather over the central United States has long been recognized. Reed in 1937 [2] pointed out the importance of subsidence and dry air aloft associated with this High cell in preventing the development of cloudiness and showers and in favoring drought. Also of significance in keeping the weather dry over a rather extensive area surrounding the High may be the stronger-than-normal southwesterly flow between the anticyclone and a deeper-than-normal trough usually located along the west coast. (See figs. 3 and 4.) This flow leads to frequent advection of air from the hot desert regions of the Southwest into central portions of the country. One other major feature generally associated with this continental High probably helps to complete the physical picture of the production of heat and drought over the central United States. This is the fast, flat westerly flow, generally found along the northern periphery of the High, which typically prevents cool Canadian polar air from making appreciable penetrations very far south of the Canadian border, so that frontal showers are minimized.

Further details of the nature of the continental anticyclone and the flow around it this June are revealed in figures 5–7. Note the axis of maximum wind speed at 700 mb. stretching from the bottom of the west coast trough over southern California northeastward to the Lakes and thence eastward across New England. Maximum speeds along this axis over the United States were located over Wisconsin directly north of the High center over Mississippi. (See fig. 4.) Meanwhile, wind speeds were extremely weak over the South along the major east-west axis of the anticyclone. Considerable anticylonic shear existed between the westerly belt across the North and the virtually stagnant flow to the South. This shear, combined with anticyclonically curved contours in figure 4, resulted in pronounced anticyclonic vorticity over a broad area from northwest Mexico east-northeastward to the Middle Atlantic States (fig. 6). The strongest anticyclonic vorticity was centered just north of the High cell over western Tennessee. It is interesting to note that the area enclosed by the -1 vorticity line in figure 6 coincided almost exactly with the region enclosed by the $+5$ anomaly line in figure 4, showing a remarkable similarity between positive height anomalies and anticylonic vorticity over the United States. Perhaps most important is the fact that this area where 700-mb. heights and anticyclonic vorticity were at a maximum also closely coincided with the large area of predominantly light precipitation extending from New Mexico to the Lakes region shown in figure 2–B or Chart III–B.

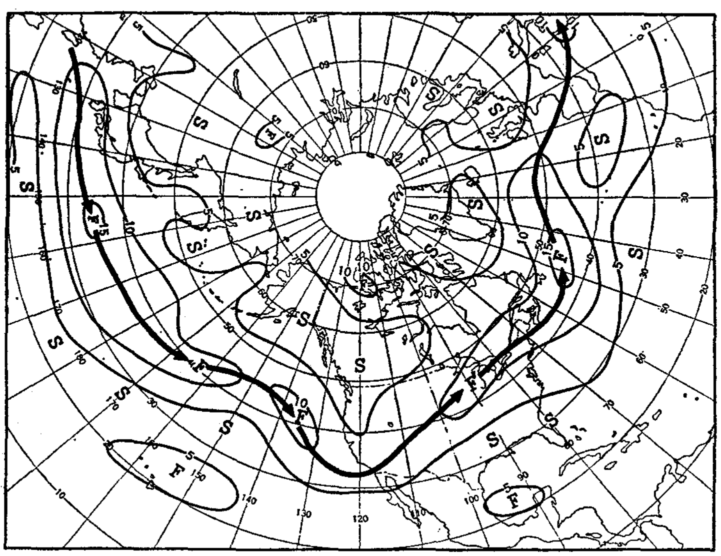


FIGURE 5.—Mean 700-mb. wind speeds (isotachs drawn at intervals of 5 m/sec) for May 30–June 28, 1953. Solid arrows indicate the average position of jet stream at this level. Relatively fast westerlies blew along the northern periphery of continental High cell centered over Mississippi. (See fig. 4.)

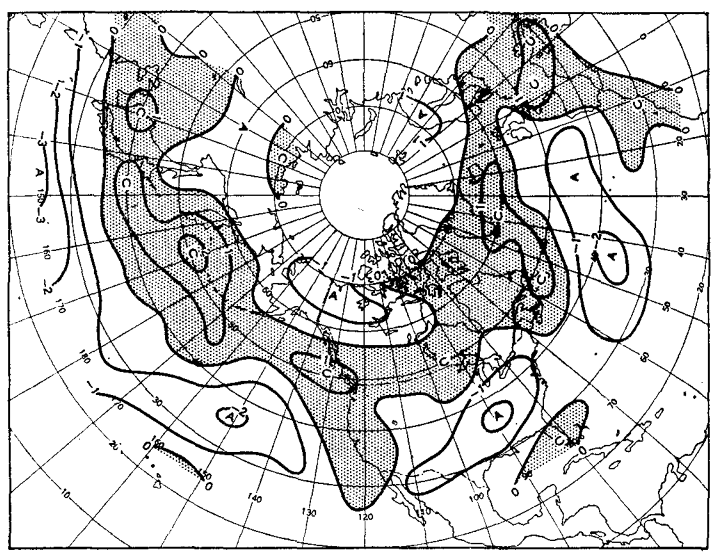


FIGURE 6.—Mean relative geostrophic vorticity at 700 mb. (in units of 10^{-5} sec^{-1}) for May 30–June 28, 1953. Areas of cyclonic vorticity are shaded and labeled "C" at centers of maximum vorticity. Centers of anticyclonic vorticity are labeled "A". Pronounced anticyclonic vorticity dominated much of the United States from the Southwest to the Northeast. This was associated with strong wind shear south of the jet shown in figure 5 and with anticyclonic curvature in the circulation around the High cell portrayed in figure 4.

Figure 7 and Charts XI and XV demonstrate that the well-developed mid-continent ridge, as well as other large-scale features of the circulation pattern, remained virtually unchanged up into the lower stratosphere. It is noteworthy, however, that at 200 mb. the High was centered in southeastern Mexico compared with its lower-level position over Mississippi at 700 mb. The axis of maximum wind speeds at 200 mb., which is also shown in figure 7, paralleled quite closely the axis at 700 mb. (fig. 5), but was generally slightly farther north from the west coast to the northern Plains. Maximum wind speeds in the 200-mb. jet over North America were located over California and Nevada. The highest value was about 32 m./sec., as much as five times as great as the speeds directly below at 700 mb. A secondary maximum was located near the Great Lakes, close to the maximum at 700 mb., but here speeds at 200 mb. were only about 2¼ times those at 700 mb. The High at 700 mb. (fig. 4) was located almost directly under the 200-mb. ridge where weak mean westerly winds of about 10 m./sec. were passing over it.

OTHER ASPECTS OF THE WEATHER AND CIRCULATION

Severe local storminess continued to dominate the weather news during the first half of June. A series of devastating tornadoes on the 8th and 9th caused the greatest loss of life and the most property damage. These were concentrated in eastern Michigan and northern Ohio on the 8th and in southeastern New Hampshire and central Massachusetts on the 9th. They occurred in connection with the eastward passage of a pronounced prefrontal squall line which in turn was associated with a deep Low which moved out of New Mexico, across Lake Superior, and eastward through southeastern Canada (Chart X). This was slightly to the south of the prevailing cyclone track shown in figure 8–B. In general most of the tornadoes in June were confined to the northern Border and central Plains States as they were in the last third of May. As pointed out last month by the author [3], the establishment of the continental anticyclone and the shifting of the main westerly belt to the northern United States early in the last decade of May brought an end to severe storminess in the South, but allowed continued storminess across the North.

Several cyclones formed or redeveloped east of the Continental Divide during June and moved north-northeastward through the northern Plains and Upper Lakes and then joined with the principal Canadian storm track (fig. 8-B or Chart X). Most of the cyclogenesis took place to the south of the mean jet stream axis at both 700 mb. and 200 mb. (figs. 5 and 7) where anticyclonic vorticity prevailed (fig. 6). Once formed, the cyclones

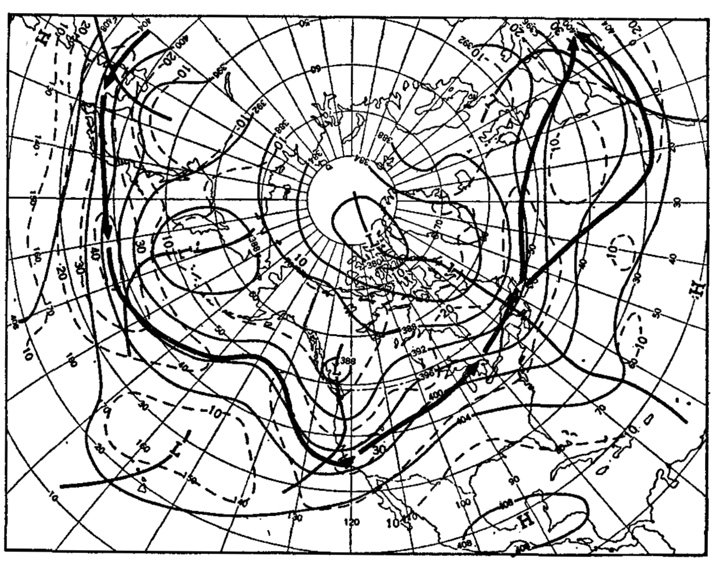


Figure 7.—Mean 200-mb. chart with contours (labeled in hundreds of feet) and isotachs (labeled in meters per second) for May 30–June 28, 1953. Note very great similarity in basic pattern to 700-mb. level (fig. 4). Solid arrows indicate the average position of jet stream, which corresponds closely with the position of 700-mb. jet over the United States (fig. 5).

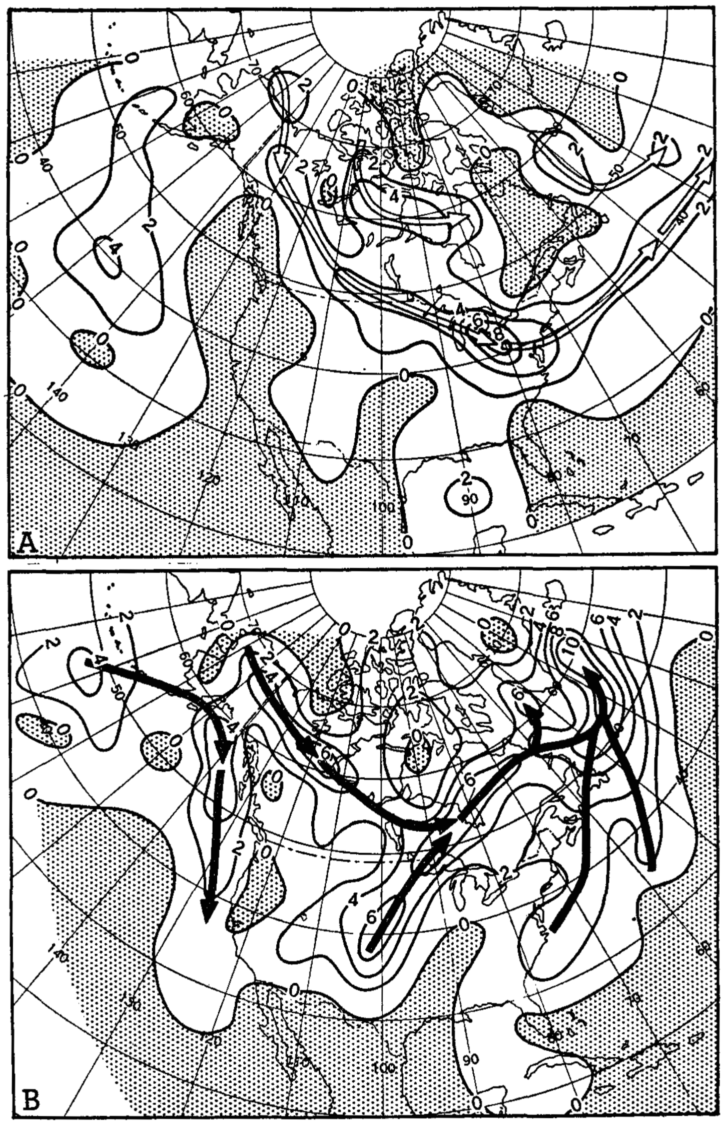


Figure 8.—Frequency of (A) anticyclone passages and (B) cyclone passages (within 5° squares at 45° N.) during June 1953. Well-defined anticyclone tracks are indicated by open arrows and cyclone tracks by solid arrows. Note well-defined anticyclone path from western Canada through Middle Atlantic States with maximum frequency in Ohio. Also noteworthy is frequent cyclonic development over Plains with track northward through Minnesota. Both cyclones and anticyclones were infrequent in the drought and heat wave area of the South Central States.

moved rapidly northward toward the center of cyclonic vorticity just north of Minnesota. Moreover they developed at a distance of some 1,000 to 1,200 miles to the east of the deeper-than-normal west coast trough. Such a large displacement between upper-level trough and sea-level cyclonic activity is frequently found in this area, but it is much larger than that normally occurring in other parts of the Northern Hemisphere. It is probably a result of both the land-sea temperature contrast, which is very pronounced over the West in June, and the topographic effects of the Rockies on the flow, which often damp out sea-level cyclones over the Plateau and create them east of the Continental Divide. If one examines the daily synoptic maps, the relationship between the west coast trough and the cyclones east of the Divide becomes more apparent. Sharp cold fronts moving across the West out of the trough provided perturbations from which new Lows formed east of the Divide. The mean sea level circulation and its departure from normal (Chart XI) reflect the cyclonic developments east of the Divide since a mean trough extended northward through the Plains from eastern Colorado to the Dakotas and a large area of negative pressure anomaly was centered over Nebraska. The cyclonic activity moving up through the Plains brought heavy amounts of precipitation to the northern Plains and the upper Mississippi Valley. Note that most of this precipitation occurred where surface flow was more easterly then normal, to the north of and under the mean jets shown in figures 5 and 7.

In the Far West the weather of June 1953 was wet and cold (figs. 1-B, 2-B). This was associated with the deep west coast trough and the very strong northerly flow on its west side (fig. 4). This flow pattern transported cold maritime polar air masses into and east of the trough, while the prevailing deep cyclonic circulation caused frequent precipitation. Note the broad region of cyclonic vorticity accompanying the trough shown in figure 6. On the west side of the trough and its cyclonic vorticity area, Low centers plunged southward just off the west coast (fig. 8-B).

The east coast of the United States (with the exception of the Northeast) experienced temperatures which averaged near to slightly below normal (fig. 1-B or Chart I-B) and precipitation amounts which were generally moderate to heavy (fig. 2-B or Chart III). At first glance this relatively cool weather on the east coast is not too easy to explain, especially when one considers the rather close resemblance between the circulation patterns of this June and last June (figs. 3 and 4) and the fact that last June was hot and prevailingly dry on the east coast (figs. 1-A and 2-A). However, there were some subtle, but significant differences in the circulation patterns which can account for cooler and wetter weather this June. First, the east coast trough was considerably farther west, south of 40° N., trailing back across southern Florida and into the Gulf of Mexico this month, so that flow along the east coast was more northerly than normal and more meridional than it was last June. Second, heights near Hudson Bay were slightly above normal this June whereas they were markedly below normal last June, so that the westerlies across southeastern Canada were not as strong as last June; and there were even several short periods in the first half of the month when the westerlies were very weak. As a result Canadian polar air was able to penetrate the entire east coast on several occasions accompanied by frontal rainfall and showers. Figure 8-A shows that the major anticyclone path across the east coast was through the Middle Atlantic States. Most of these Highs formed as breakoffs from the mean Highs in the Pacific or northern Canada (Chart XI) and moved southeastward across the Lakes to the Atlantic Coast, bringing fresh supplies of polar air into the east coast. Cyclogenesis occurred several times just along the east coast in association with the coastal trough (Chart X). This cyclone track extended northeastward into a region of strong cyclonic vorticity aloft near Newfoundland, and there joined with the Canadian storm track to form a region of very high frequency of migratory storms south of Greenland (figs. 6 and 8-B).

In conclusion a word may be said about the disastrous floods which occurred in Japan near the end of June. These floods were termed unprecedented in modern history with a death toll of over 1,000, more than 60,000 people homeless, and widespread property damage. The monthly mean circulation pattern in that area (fig. 4) consisted of a trough along the Asiatic east coast which was slightly deeper than normal and a subtropical High cell south of Japan which was much stronger than normal. It is believed that the broad abnormally strong southwesterly flow over the China Sea and Japan, transporting copious amounts of moist air from Southeast Asia, led to frequent heavy rainfall during the month which culminated in the disastrous flood conditions at month's end.

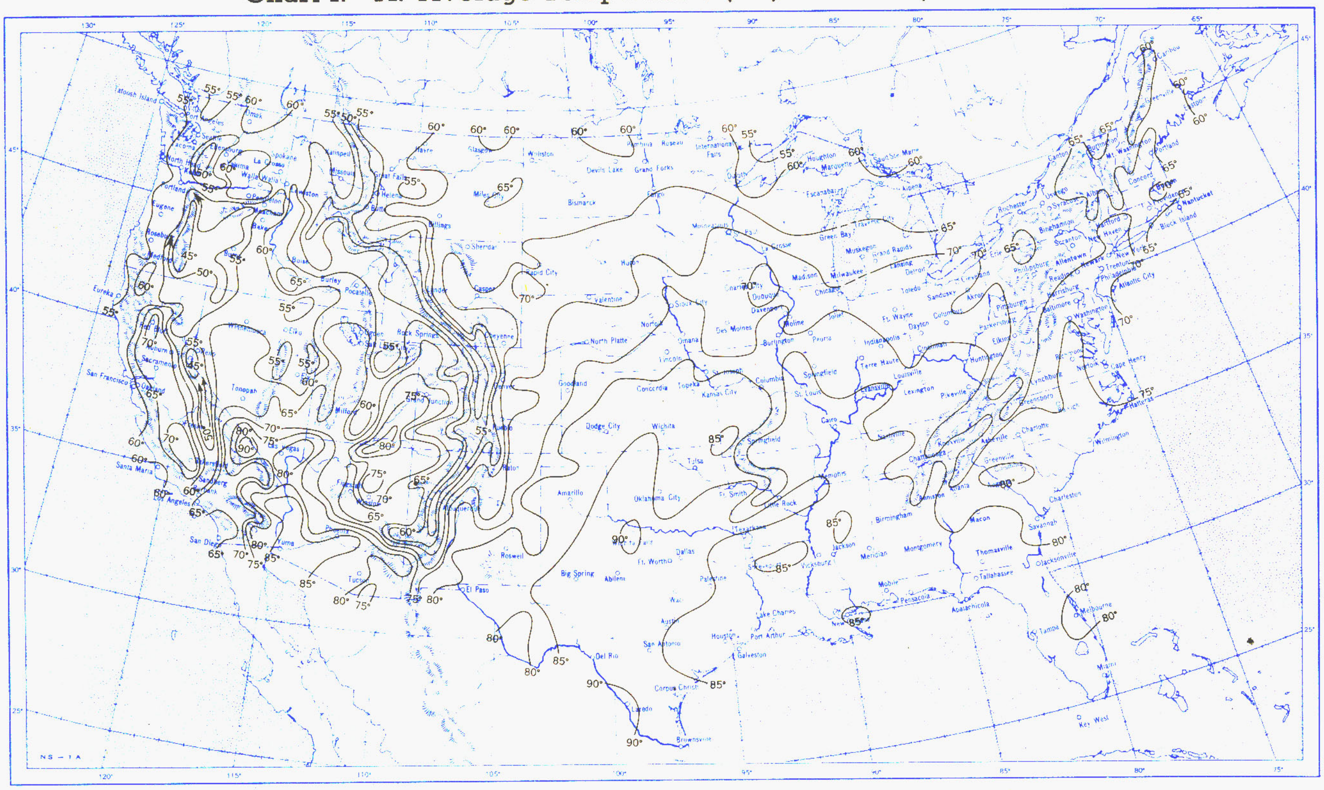
REFERENCES

1. W. H. Klein, "The Weather and Circulation of June 1952—A Month with a Record Heat Wave," *Monthly Weather Review*, vol. 80, No. 6, June 1953, pp. 99-104.

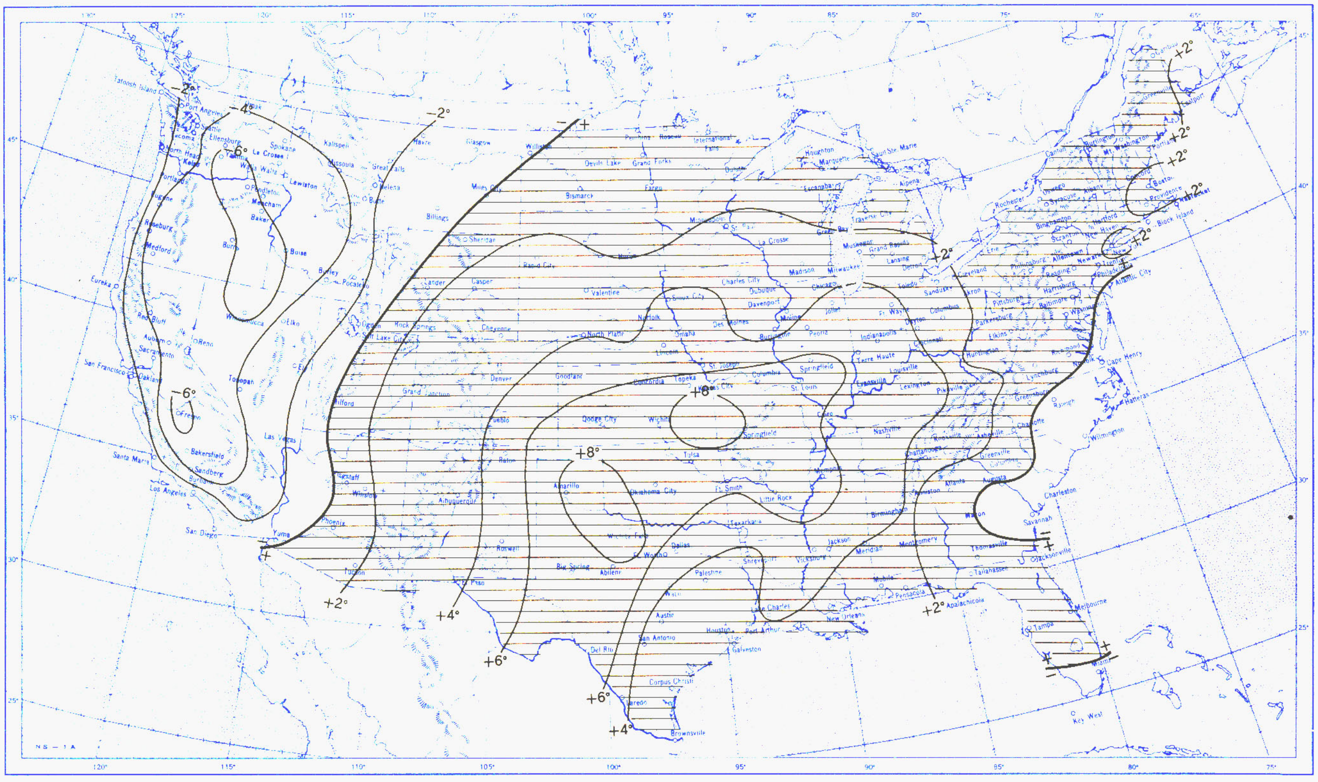
2. T. R. Reed, "Further Observations on the North American High-Level Anticyclone," *Monthly Weather Review*, vol. 65, No. 10, Oct. 1937, pp. 364-366.

3. J. S. Winston, "The Weather and Circulation of May 1953—One of the Worst Tornado Months on Record," *Monthly Weather Review*, vol. 81, No. 5, May 1953, pp. 135-140.

Chart I. A. Average Temperature (°F.) at Surface, June 1953.

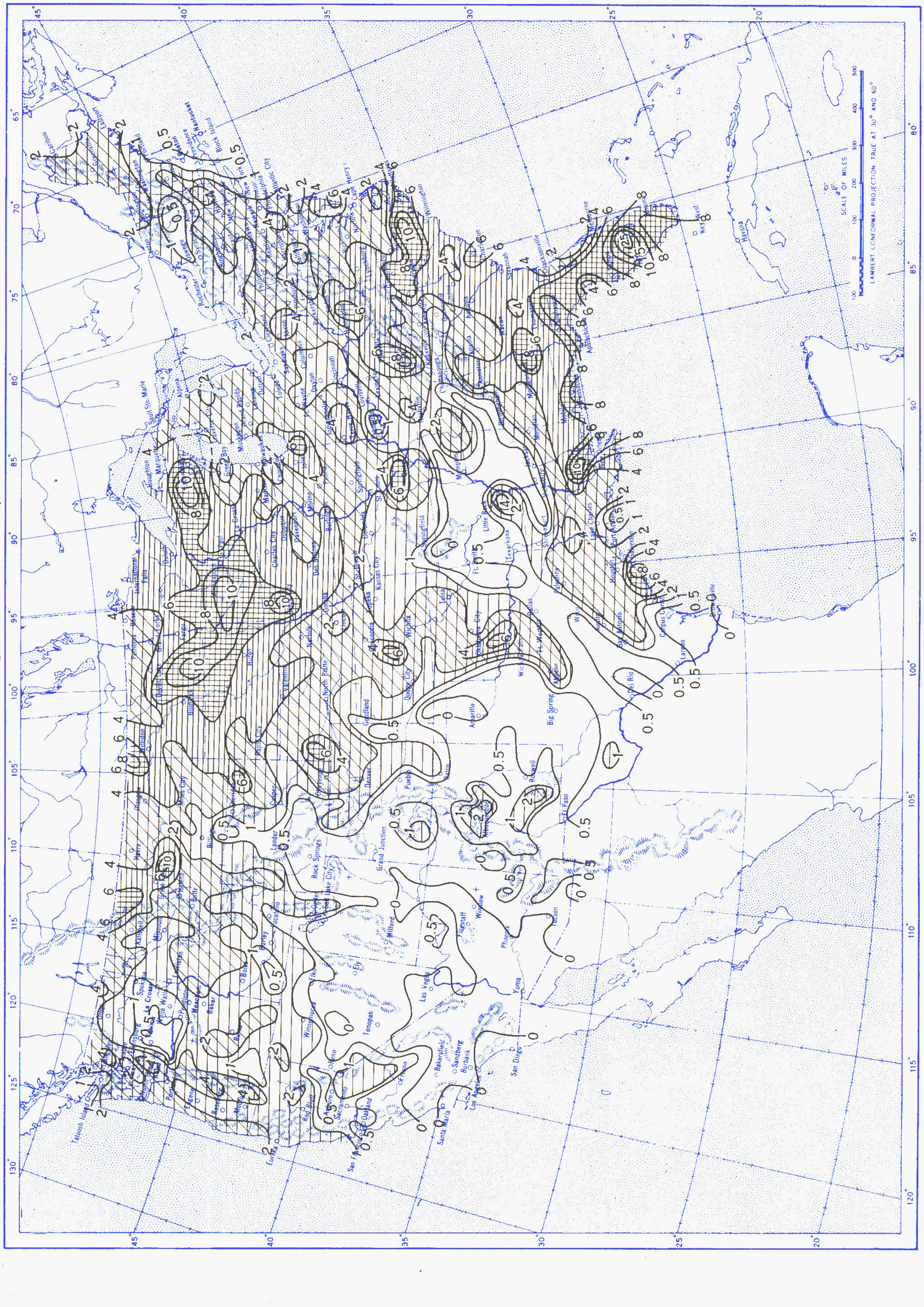


B. Departure of Average Temperature from Normal (°F.), June 1953.



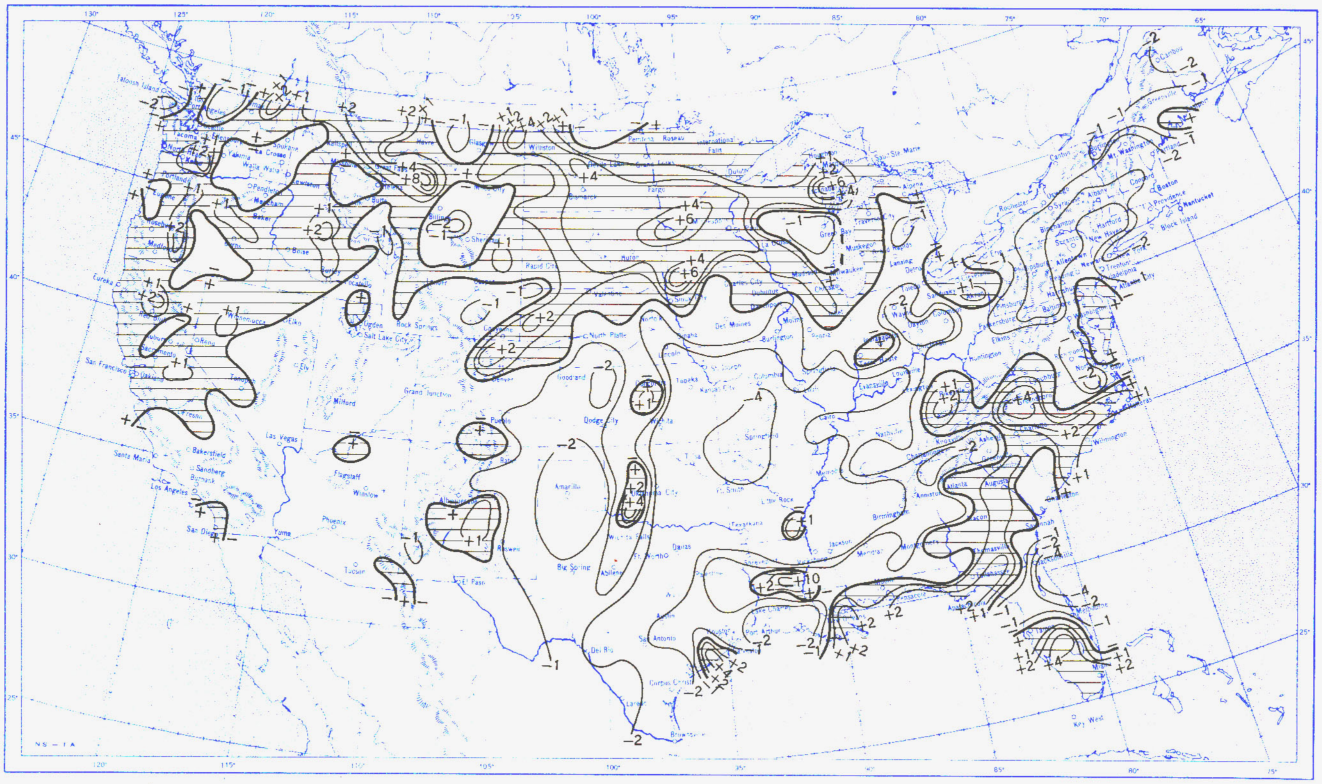
A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

Chart II. Total Precipitation (Inches), June 1953.

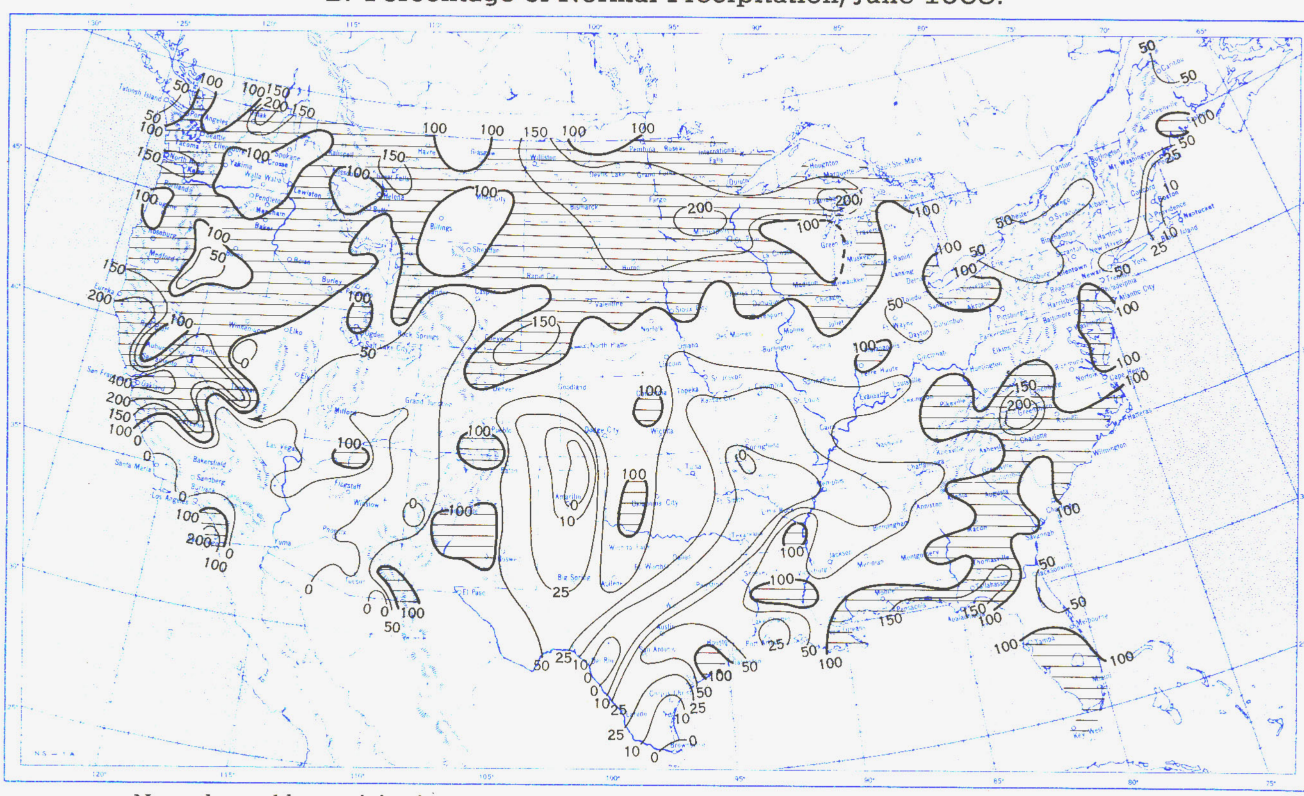


Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), June 1953.

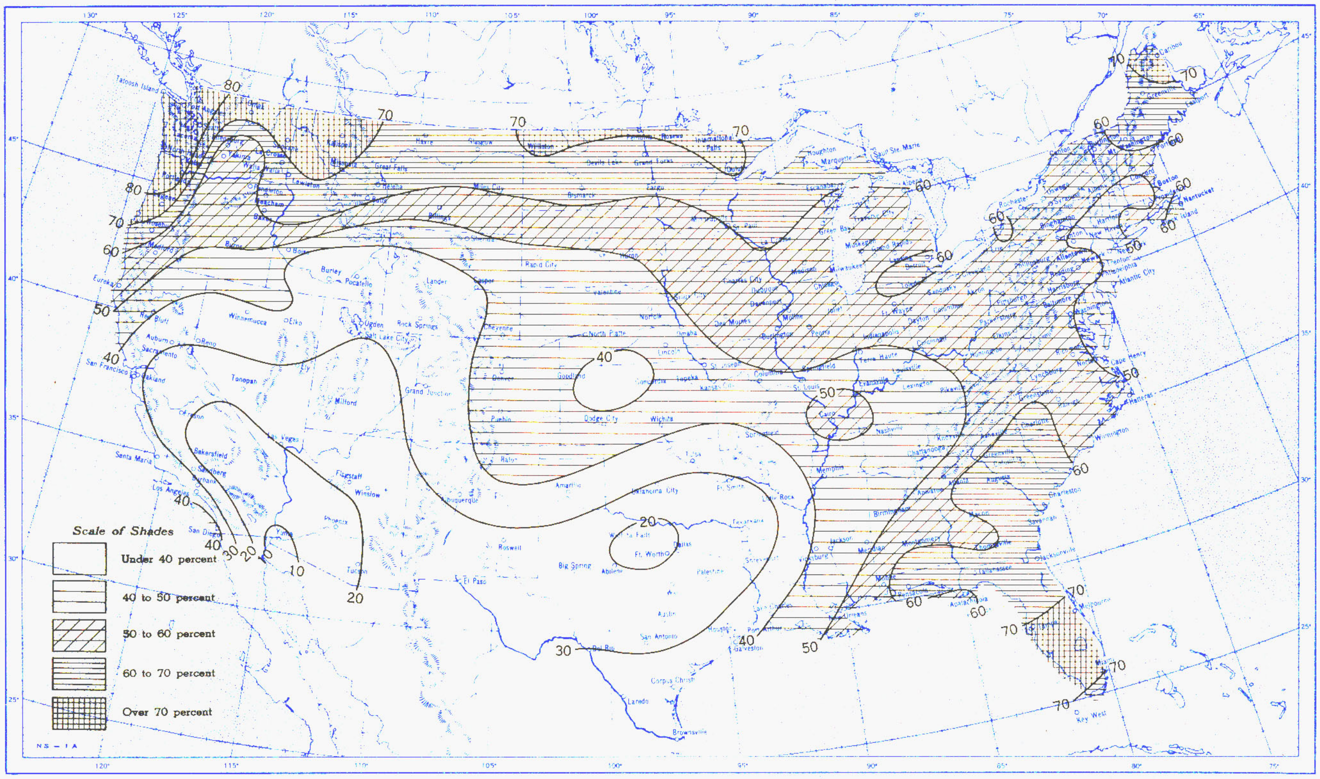


B. Percentage of Normal Precipitation, June 1953.

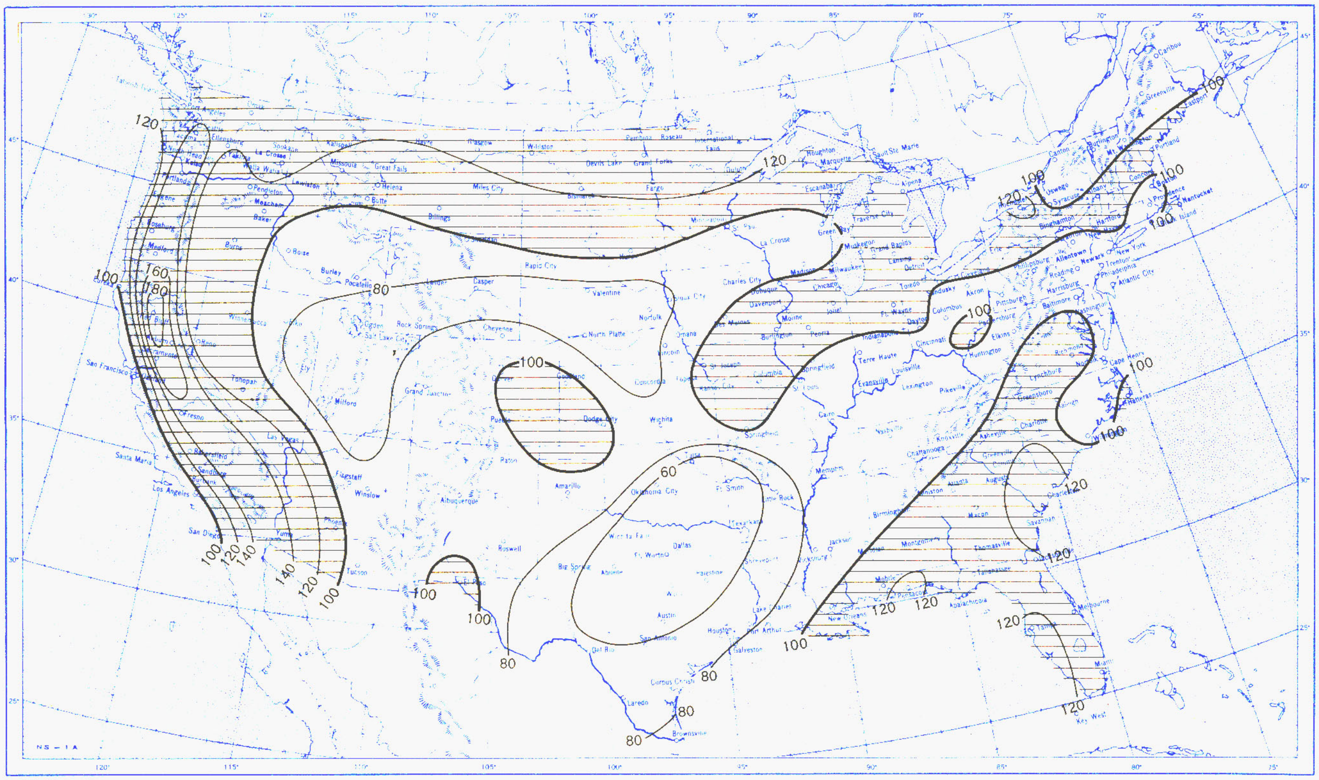


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, June 1953.

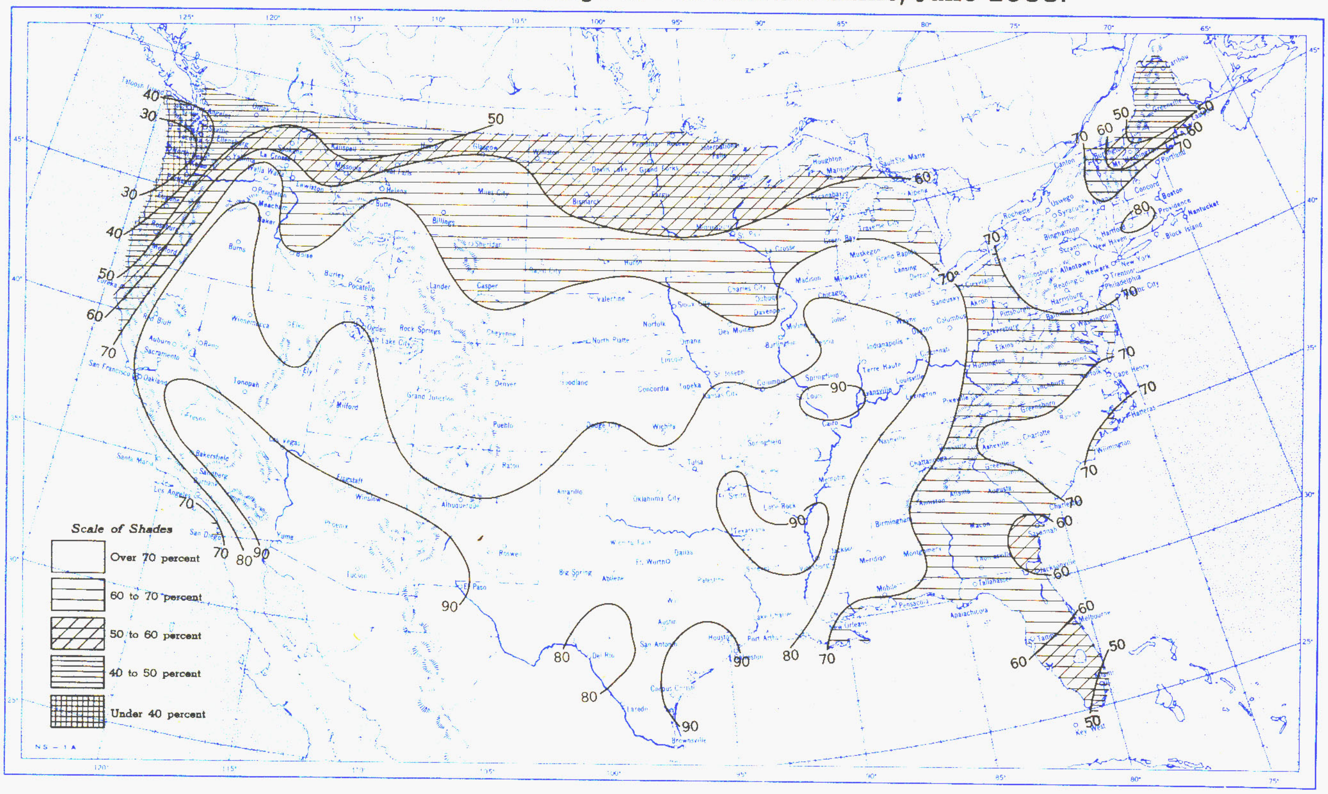


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, June 1953.

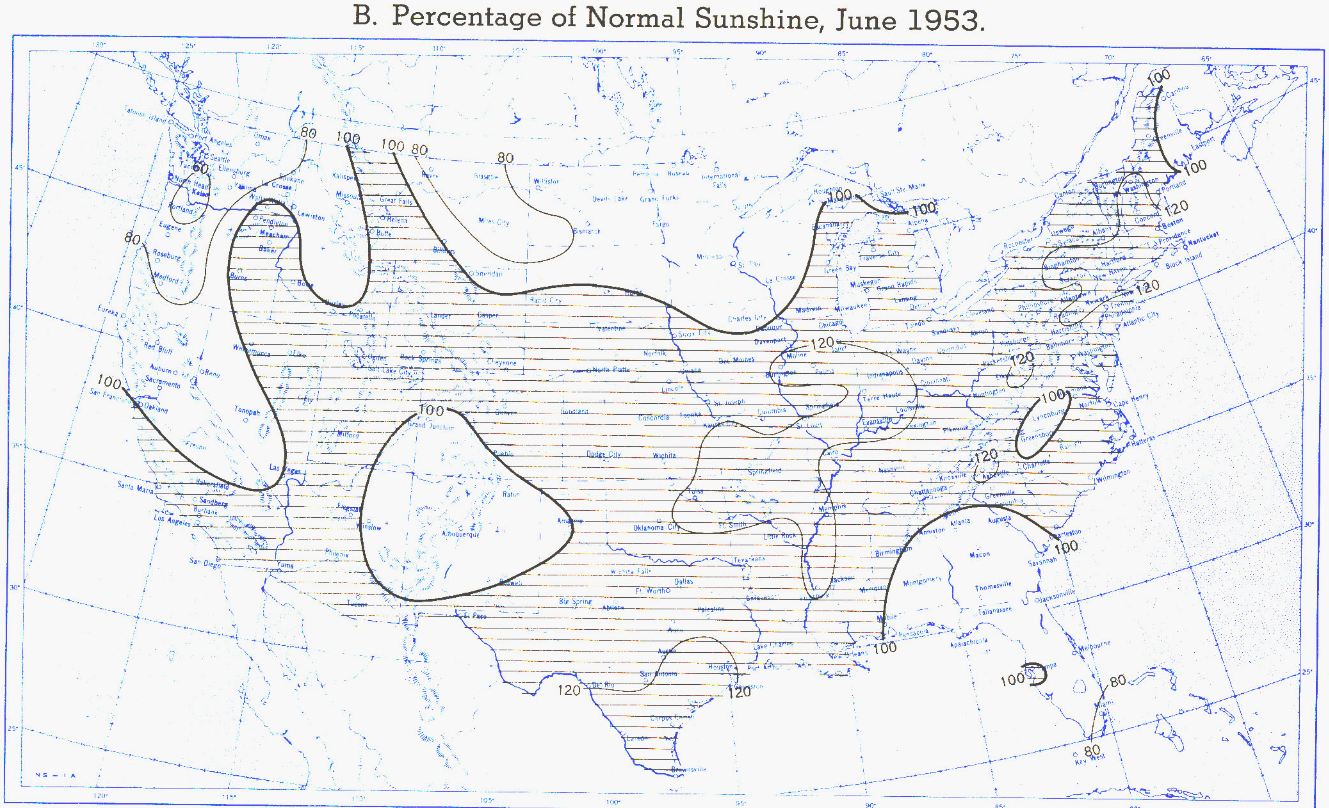


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, June 1953.



B. Percentage of Normal Sunshine, June 1953.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, June 1953. Inset: Percentage of Normal Average Daily Solar Radiation, June 1953.

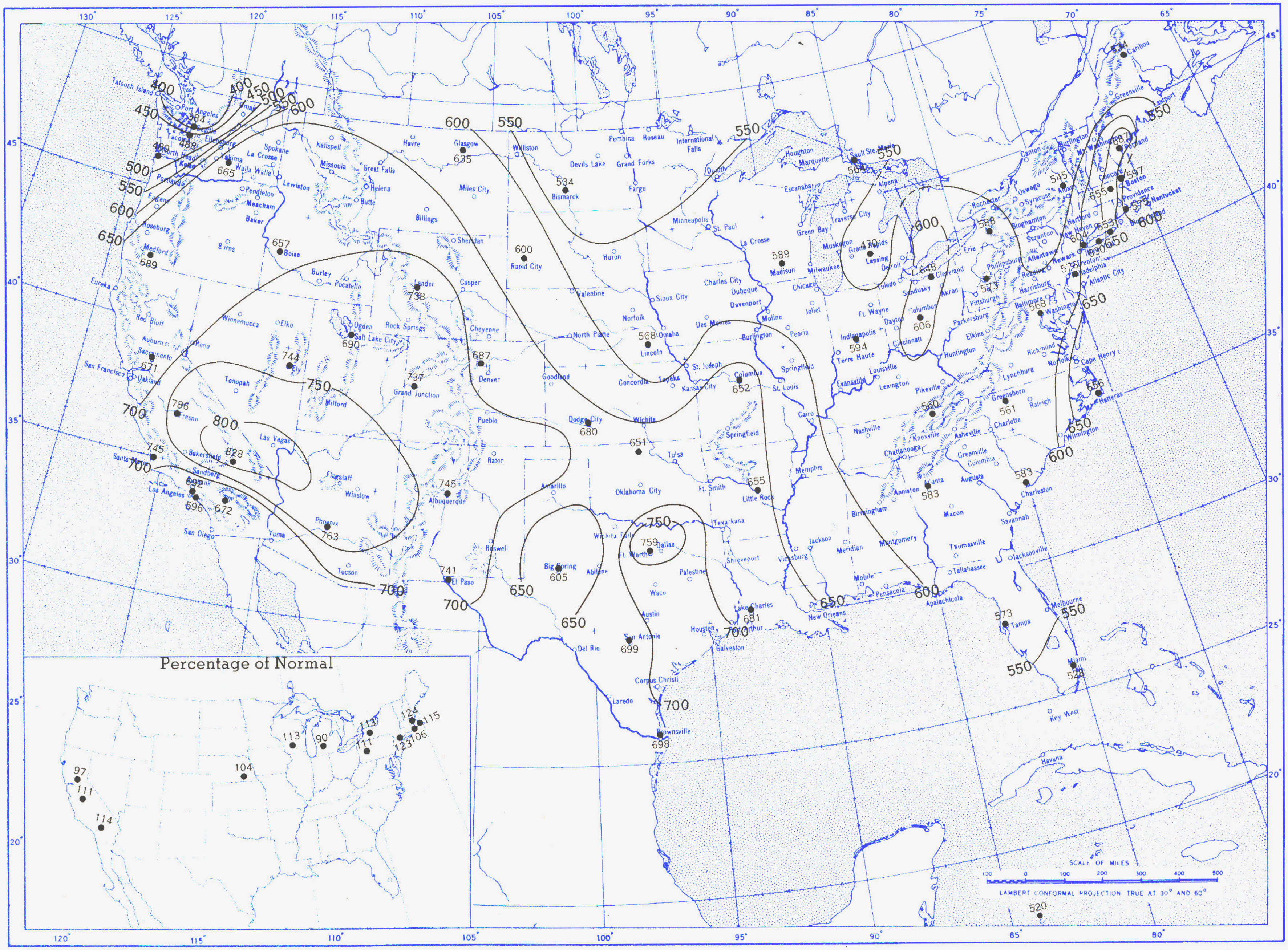
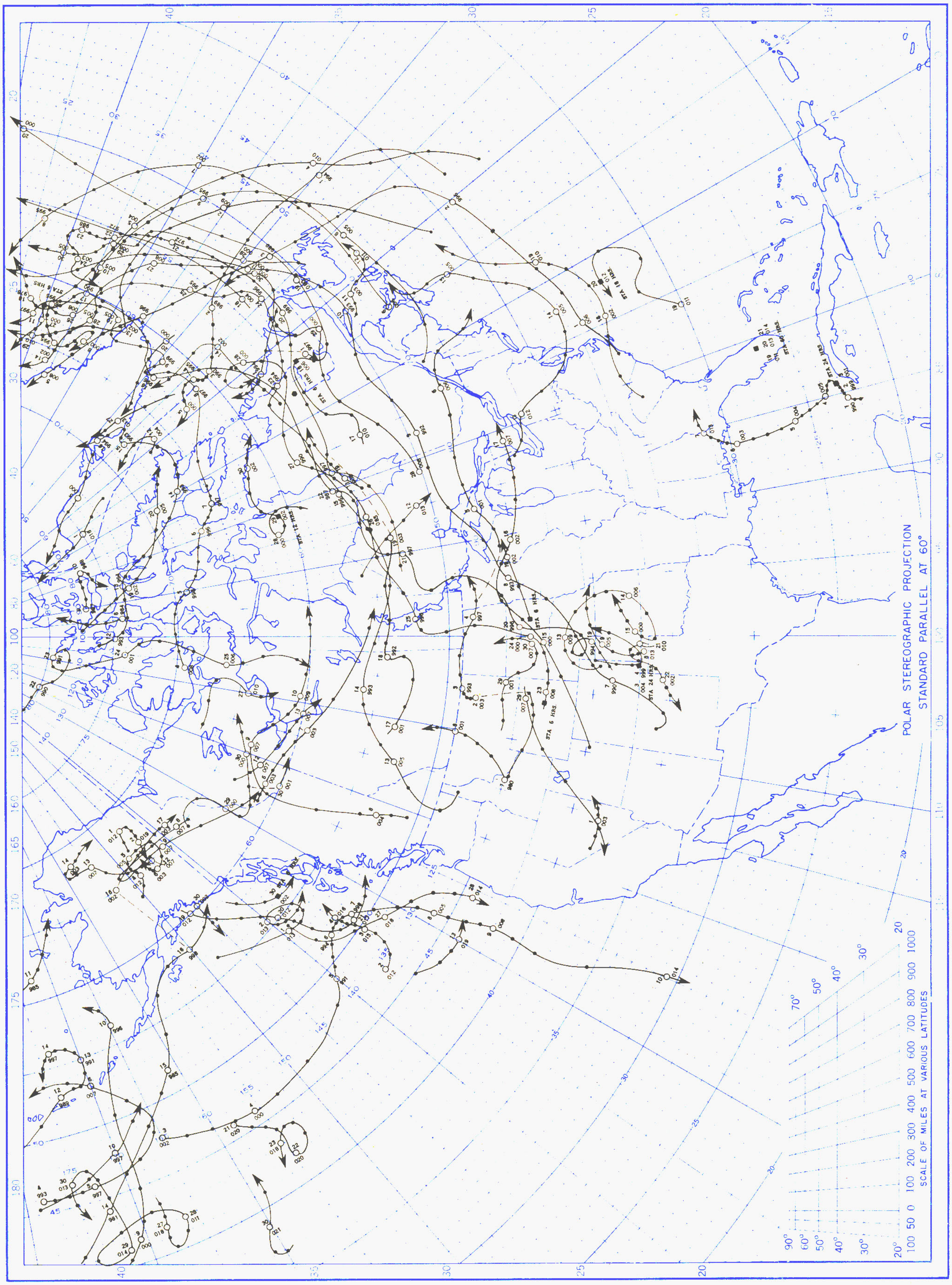


Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, June 1953.

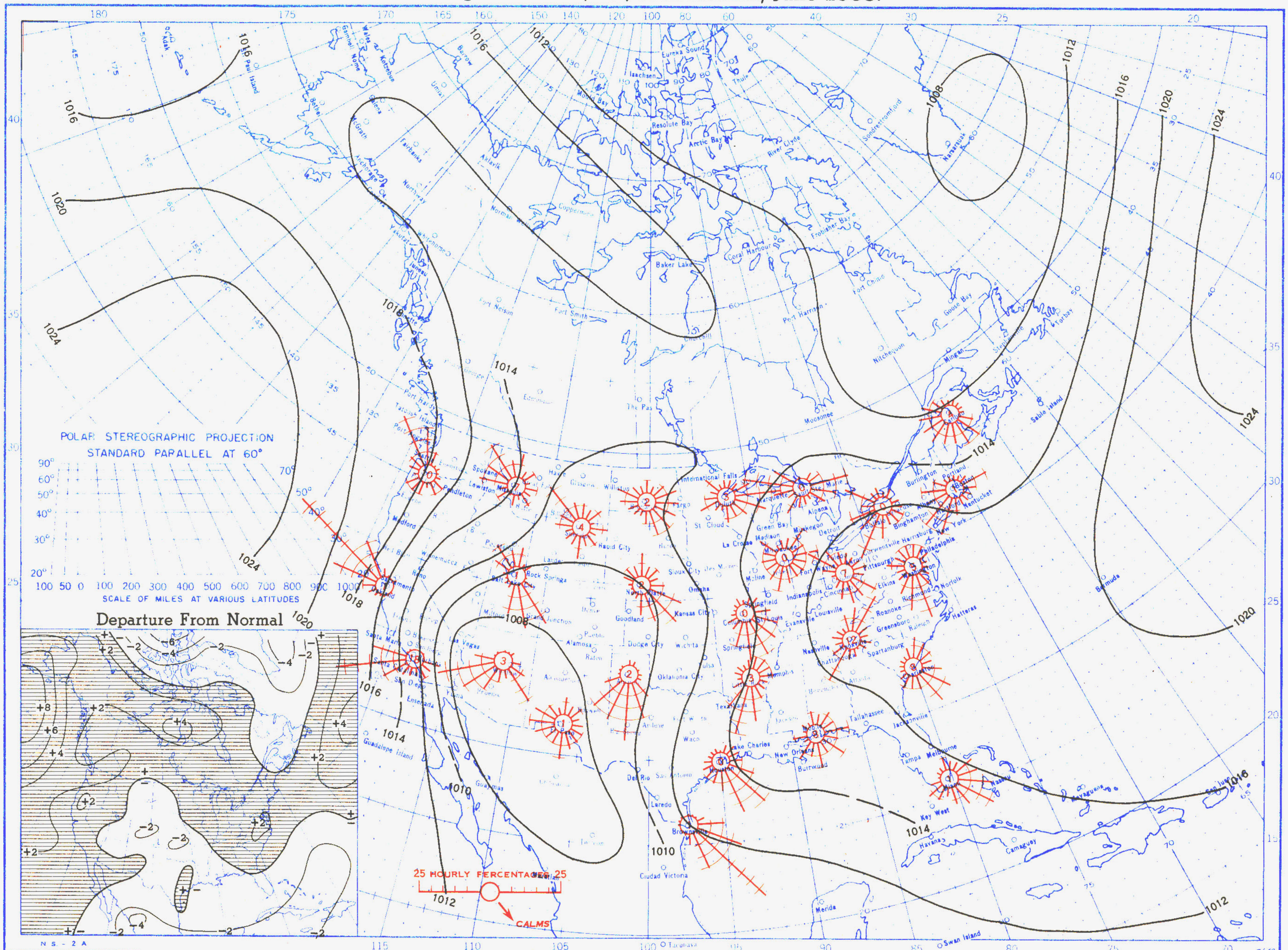
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, June 1953.



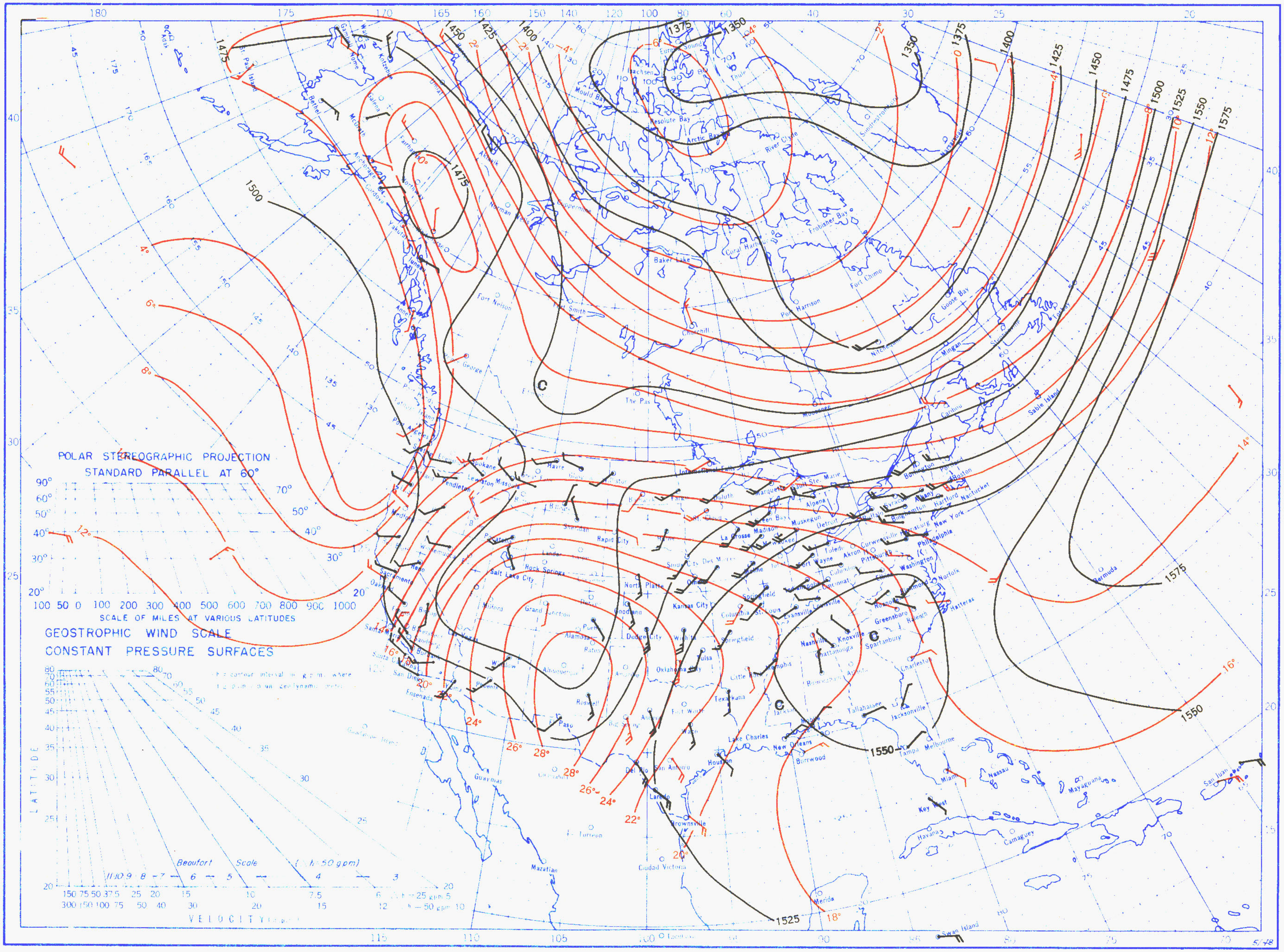
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, June 1953. Inset: Departure of Average Pressure (mb.) from Normal, June 1953.



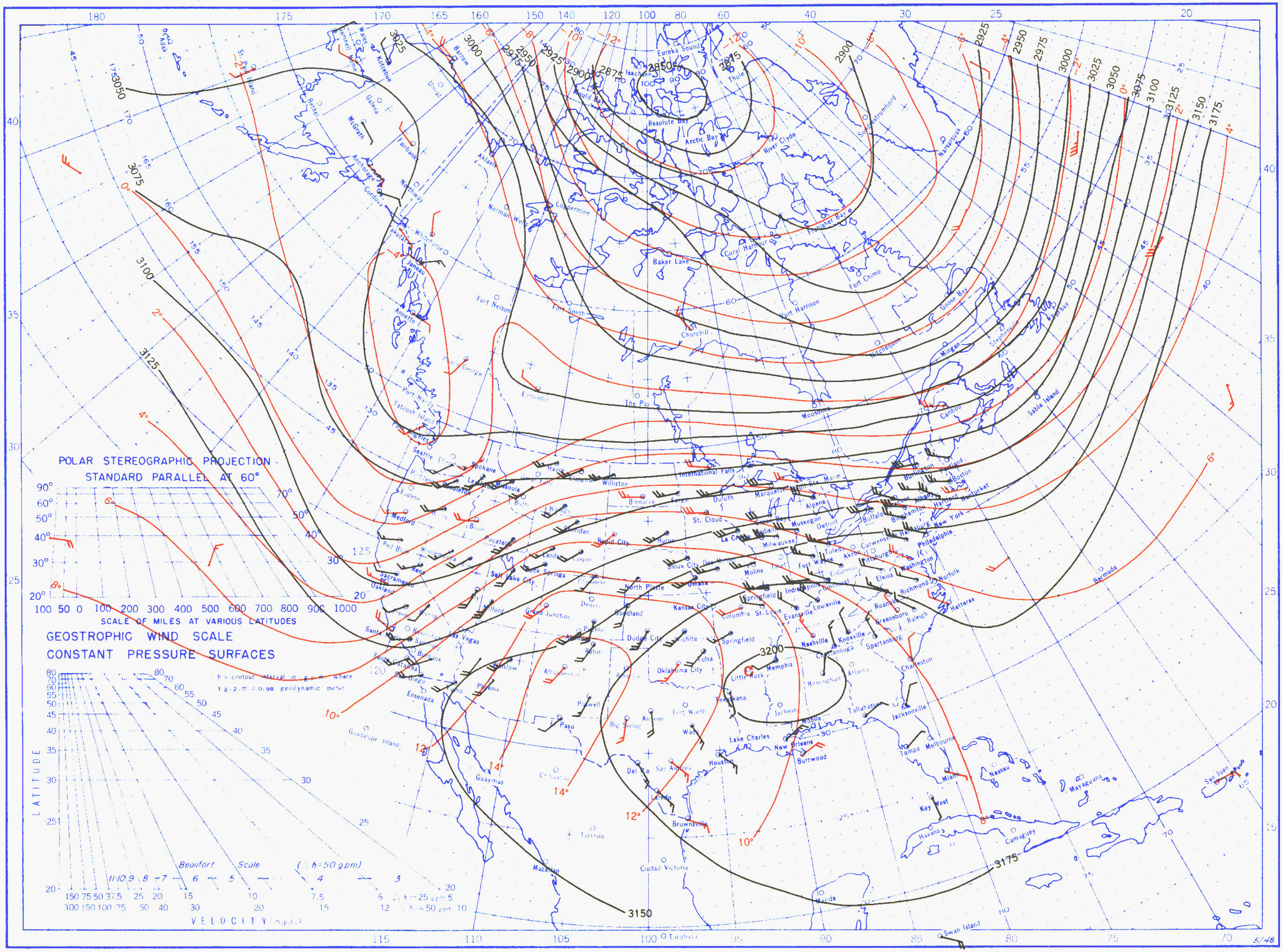
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), June 1953.



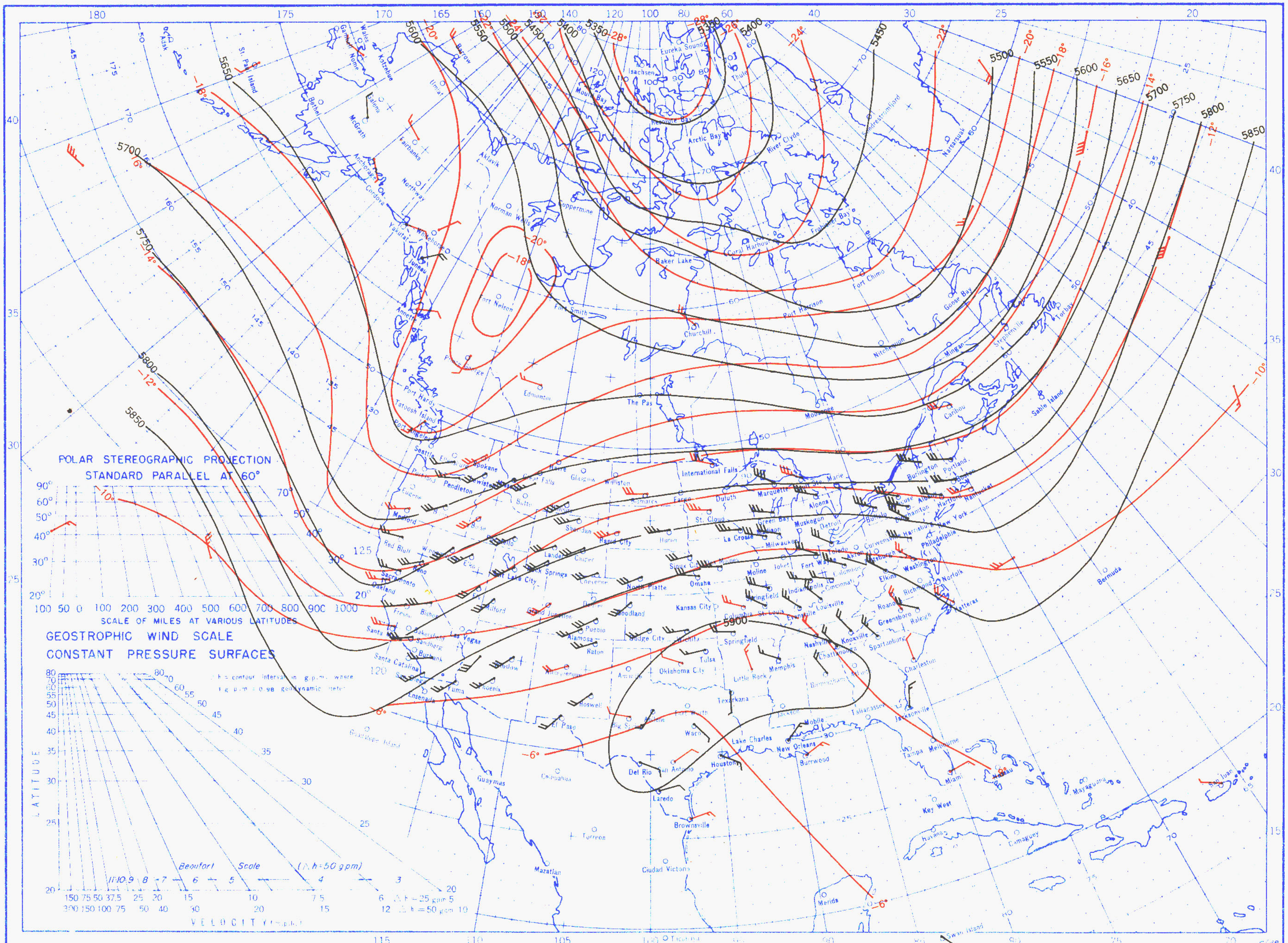
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), June 1953.



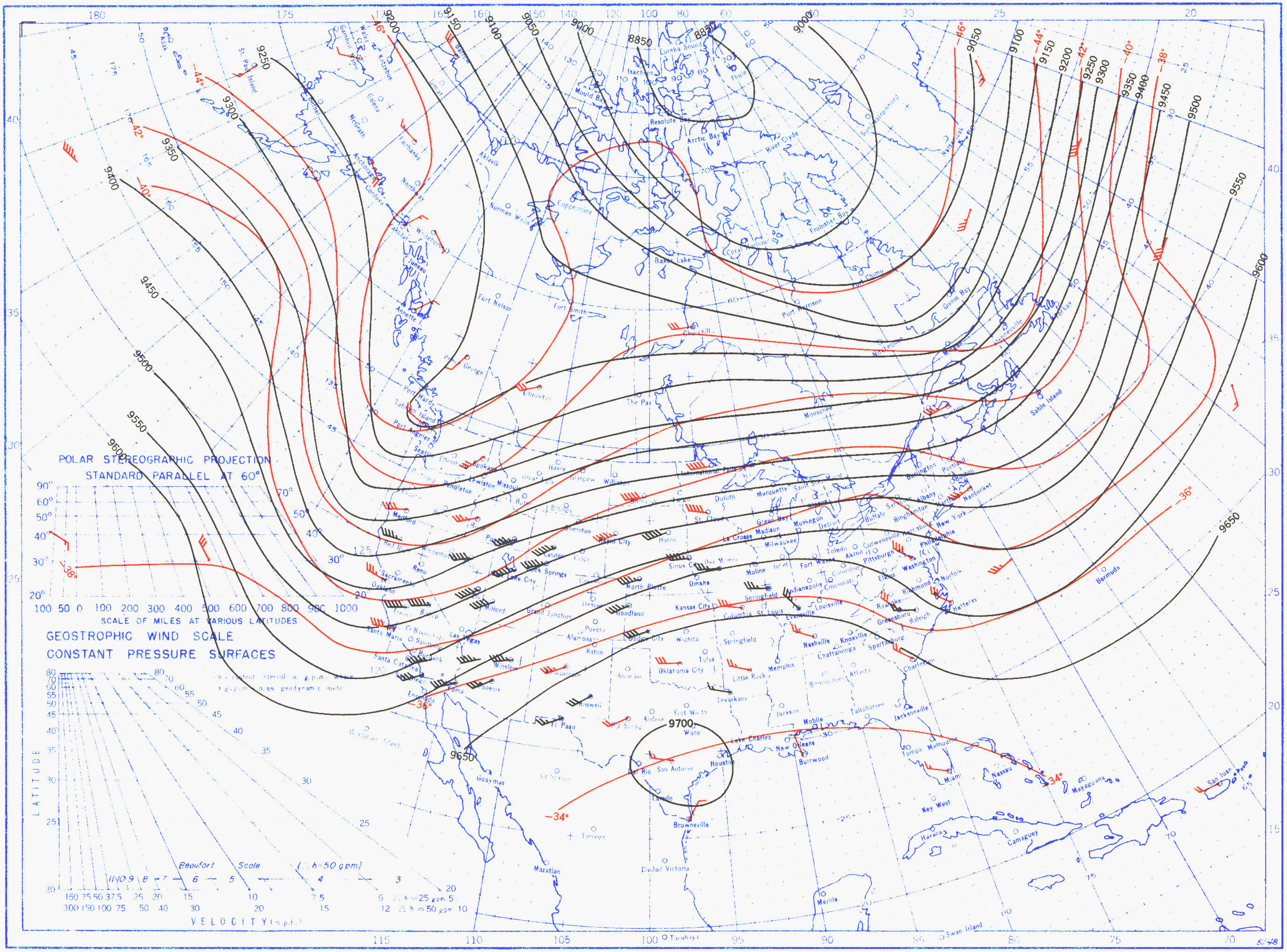
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), June 1953.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), June 1953.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.